REMARKS

In view of the above amendments and the following remarks, reconsideration and further examination are requested.

The specification and abstract have been reviewed and revised to make a number of editorial revisions. Due to the number of changes involved, a substitute specification and abstract have been prepared and are submitted herewith. No new matter has been added. Enclosed is a marked-up copy of the specification and abstract indicating the changes incorporated therein.

Claims 1, 2 and 4 have been rejected under 35 U.S.C. §102(e) as being anticipated by Nakatsuka (US 6,280,828). Claims 9, 12, 15 and 17 have been rejected under 35 U.S.C. §102(e) as being anticipated by Jiang (US 6,184,064). Claims 3 and 7 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Nakatsuka. Claims 5 and 6 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Nakatsuka in view of Miyachi (US 6,101,237). Claims 11, 13 and 16 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Jiang in view of Fujii (US 6,429,506).

Claims 8, 10 and 14 have been indicated as containing allowable subject matter. Claims 18 and 19 have been allowed. The Applicants would like to thank the Examiner for this indication of allowable subject matter.

Claims 9 and 15 have been amended so as to further distinguish the present invention from the references relied upon in the rejections.

Further, claims 8-19 have been amended to make a number of editorial revisions. These revisions have been made to place the claims in better U.S. form. None of these amendments have been made to narrow the scope of protection of the claims, nor to address issues related to patentability and therefore, these amendments should not be construed as limiting the scope of equivalents of the claimed features offered by the Doctrine of Equivalents.

In addition, claims 20-24 have been added.

The above-mentioned rejections are respectfully traversed for the following reasons.

Claim 1 is patentable over Nakatsuka, since claim 1 recites a semiconductor device including, in part, a semiconductor element including an electrode formed on an electrode-formed surface

thereof, the semiconductor element being bonded to a reinforcing member with an adhesive. Nakatsuka fails to disclose or suggest a semiconductor element as recited in claim1.

Nakatsuka discloses a flexible wiring board having a base layer 1 adhered to a reinforcing layer 4 with an adhesive layer 9. (See column 3, lines 58-65 and Figure 1). The rejection indicates that the base layer 1 corresponds to the claimed semiconductor element. However, it is apparent that the base layer 1 is merely a piece of insulating material and not a semiconductor element including an electrode formed on an electrode-formed surface. (See column 2, lines 31-35). As a result, Nakatsuka fails to disclose or suggest the present invention as recited in claim 1.

Claim 3 is patentable over Nakatsuka, since claim 3 recites that the adhesive bonds only a center of the back surface of the semiconductor element to the reinforcing member. Nakatsuka fails to disclose or suggest this feature.

Instead, Nakatsuka discloses that the adhesive layer 9 completely covers the back surface of the base layer 1 which is adhered to the reinforcing layer 4. (See Figure 1). The rejection indicates that having only the center of the back surface of the base layer 1 bonded to the reinforcing layer would be an obvious change in size of the adhesive layer 9, relying on In re Rose. However, the change in size of the adhesive layer 9 does not render obvious the recitation in claim 3 that the adhesive bonds only the center of the back surface of the semiconductor element. As a result, Nakatsuka fails to disclose or suggest the present invention as recited in claim 3.

Claim 4 is patentable over Nakatsuka, since claim 4 recites that the reinforcing member has a flexural rigidity greater than a flexural rigidity of the semiconductor element. Nakatsuka fails to disclose or suggest this feature.

Nakatsuka discloses that both the reinforcing layer 4 and the base layer 1 have high elasticities. (See column 5, lines 34-37). However, it is apparent that Nakatsuka fails to disclose or suggest the reinforcing layer 4 has a flexural rigidity greater than a flexural rigidity of the base layer 1. As a result, Nakatsuka fails to disclose or suggest the present invention as recited in claim 4.

Claim 5 is patentable over the combination of Nakatsuka and Miyachi, since claim 5 recites that the reinforcing member is larger than the semiconductor element in outside shape. The combination of Nakatsuka and Miyachi fails to disclose or suggest this feature of claim 5.

In the combination, Miyachi is relied upon as disclosing this feature of claim 5. Miyachi discloses an X-ray mask structure having a holding frame 1 with holds a membrane 2 which has an X-ray absorptive material 3 corresponding to a pattern to be printed formed thereon. The holding frame 1 is fixed to a reinforcing member 4, which surrounds the holding frame 1, with an adhesive agent 5. (See column 3, lines 27-62). The rejection indicates that the holding frame 1 corresponds to the semiconductor element recited in claim 5, while the reinforcing member 4 corresponds to the reinforcing member. However, it is apparent that the holding frame 1 in no way corresponds to the semiconductor element, since the holding frame 1 is a support element used to hold the membrane 2. This is completely different than the semiconductor element recited in claim 5.

Further, the invention disclosed in Miyachi is non-analogous art that cannot be properly used as a reference under 35 U.S.C. §103(a). As held by the Federal Circuit in Union Carbide Corp. v. American Can Co., 220 USPQ 584, 588 (1984), prior art is analogous if it is either within the field of endeavor or if it is reasonably pertinent to the particular problem faced by the inventor. Further, the test for whether a reference is relevant art is a two part test as set forth by the CCPA in In re Wood, 202 USPQ 171, 174 (1979). Under this test, it first must be determined if the reference is within the field of the inventor's endeavor. If the reference is not, it then must be determined if the reference is reasonably pertinent to the particular problem in which the inventor was involved.

The invention of Miyachi concerns a type of X-ray mask which is a completely different from the field of semiconductor devices. In addition, the purpose of the reinforcing member 4 of Miyachi is to support a pellicle 6 which serves to close a space at a workpiece side of the membrane 2 which differs from the purpose of the reinforcing member of claim 5. (See column 3, lines 58-63). As a result, it is apparent that the combination of Nakatsuka and Miyachi is improper and fails to disclose or suggest the present invention as recited in claim 5.

Claim 6 is patentable over the combination of Nakatsuka and Miyachi, since claim 6 recites that the reinforcing member includes a recess portion to which the semiconductor element is bonded, and a projection formed at a border of the recess portion. The combination of Nakatsuka and Miyachi fails to disclose or suggest these features of claim 6 for the same reasons set forth above with regard to claim 5. That is, the holding frame 1 in no way corresponds to the semiconductor element and the combination of Nakatsuka and Miyachi is improper, since Miyachi is non-analogous art.

Claim 9 is patentable over Jiang, since claim 9 discloses a method of manufacturing a semiconductor device including, in part, dividing a semiconductor wafer to which a reinforcing plate is bonded and the reinforcing plate into units of semiconductor elements, the reinforcing plate being operable to be held by a mounting head when the semiconductor elements are being mounted to a substrate. Jiang fails to disclose or suggest this feature of claim 9.

Jiang discloses a semiconductor component 100 having an active surface 102 mounted to a carrier substrate 144, such as a printed circuit board. A number of bond wires 148 connect the active surfaces 102 of the semiconductor component 100 to electrical contacts on the carrier substrate 144. (See column 8, lines 8-19 and Figure 4A).

The rejection indicates that the carrier substrate 144 corresponds to the reinforcing plate recited in claim 9. However, claim 9 recites that the reinforcing plate is bonded to the semiconductor elements and that the reinforcing plate is operable to be held by mounting head when the semiconductor elements are being mounted to a substrate. Since the carrier substrate 144 of Jiang is disclosed as being a printed circuit board and the carrier substrate 144 is electrically connected to the semiconductor element 100 with the bond wires 148, it is apparent that the carrier substrate 144 is an element which the semiconductor component 100 is to be mounted for operation. Therefore, it is apparent that the carrier substrate 144 corresponds to the substrate recited in claim 9 instead of the reinforcing plate because the reinforcing plate is operable to be held by a mounting head for mounting the semiconductor elements, not for having the semiconductor elements mounted thereon for operating the semiconductor elements. As a result, Jiang fails to disclose or suggest this limitation of claim 9.

As for claim 15, it is patentable over Jiang for similar reasons to those set forth above with regard to claim 9. That is, claim 15, similar to above claim 9, recites bonding a reinforcing member to a back surface of each of the semiconductor elements with an adhesive, the reinforcing member being operable to be held by a mounting head when the semiconductor elements are being mounted to a substrate, which feature is not disclosed or suggested by the reference.

Claim 13 is patentable over the combination of Jiang and Fujii, since claim 13 recites a method of manufacturing a semiconductor device including, in part, dividing a semiconductor wafer into semiconductor elements by shaving a back surface of the semiconductor wafer to thin the

semiconductor wafer to a thickness until the shaved back surface reaches a diced groove. The combination of Jiang and Fujii fails to disclose or suggest this feature of claim 13.

Jiang discloses a semiconductor component 100 that has a number of integrated circuit patterns form thereon. Once the circuit patters have been formed, a back side surface 104 of the semiconductor component 100 is thinned by grinding to remove a portion of the material. After the thinning, the back side surface 104 of the semiconductor component 100 is textured to exhibit an irregular roughness so that the back side surface 104 can be adhered to a wafer tape 114. Once the semiconductor component 100 is adhered to the wafer tape 114, it can be divided into separate semiconductor components 100. (See column 8, line 59 - column 10, line 9).

The rejection indicates that Jiang fails to disclose or suggest forming diced grooves in a top side of a semiconductor, attaching a cover sheet to protect an electrode on a surface of a semiconductor, or dividing a semiconductor wafer by shaving a back side surface of the semiconductor. As a result, Fujii is relied on in the combination as disclosing these features.

Fujii discloses a method of fabricating a semiconductor that includes applying a dicing tape 12a to a first surface of a semiconductor wafer 11, applying a protective cap 63 to a second surface of the semiconductor wafer 11, cutting a number of grooves 6 in the semiconductor wafer 11, but not through the dicing tape 12a, and then removing the dicing tape 12a so that a number of individual semiconductor chips 400 are formed. (See column 7, line 17 - column 8, line 17 and Figures 11A - 11E). However, from this description, it is apparent that Fujii fails to disclose or suggest that the semiconductor wafer 11 is divided into the semiconductor chips by shaving the first surface of the semiconductor wafer 11 to thin the semiconductor 11 wafer to a thickness until the shaved back surface reaches the grooves 6. Instead, it appears that the dicing tape 12a is merely peeled off. As a result, the combination of Jiang and Fujii fails to disclose or suggest the present invention as recited in claim 13.

Because of the above mentioned distinctions, it is believed clear that claims 1-24 are allowable over the references relied upon in the rejections. Furthermore, it is submitted that the distinctions are such that a person having ordinary skill in the art at the time of invention would not have been motivated to make any combination of the references of record in such a manner as to result in, or

otherwise render obvious, the present invention as recited in claims 1-24. Therefore, it is submitted that claims 1-24 are clearly allowable over the prior art of record.

In view of the above amendments and remarks, it is submitted that the present application is now in condition for allowance. The Examiner is invited to contact the undersigned by telephone if it is felt that there are issues remaining which must be resolved before allowance of the application.

Respectfully submitted,

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SEMICONDUCTOR DEVICE, METHOD OF MANUFACTURING THE DEVICE AND METHOD OF MOUNTING THE DEVICE

FIELD OF THE INVENTION

[0001] The present invention relates to a semiconductor device including a semiconductor element and a reinforcing member bonded to a back surface opposite to an electrode-formed surface of the element with an adhesive and also relates to a method of manufacturing the device and a method of mounting the device.

BACKGROUND OF THE INVENTION

[0002] A semiconductor device mounted to electronic equipment is manufactured through a packaging process of connecting pins, metallic bumps or the like of a lead frame to a semiconductor element in the form of a wafer on which a circuit pattern is formed and of sealing the element with resin or the like. With recent miniaturization of the electronic equipment, the size of semiconductor ~~device~~ devices has ~~the size~~ become small and ~~has~~ the semiconductor element has become thin.

[0003] The thinned semiconductor element is susceptible to ~~a~~ damage during ~~in a~~ handling because of the low strength of the element against external force. Accordingly, a conventional semiconductor device has the thinned semiconductor element generally sealed with a layer of resin for reinforcement.

[0004] In a process of forming the resin layer on the surface of the thin semiconductor element, contraction and shrinkage of the resin layer likely cause ~~a problem~~ problems such as warpage and fracture to the semiconductor element. The problem becomes more apparent as the semiconductor element is thinned~~;~~. ~~for~~ For example, an extremely thin semiconductor element having a thickness of 100μm or less is hardly sealed with resin.

OK to enter JA 12/1/03

SUMMARY OF THE INVENTION

[0005] A semiconductor device includes a semiconductor element having an electrode-formed surface including an electrode for external connection formed thereon, and a reinforcing member bonded to a back surface opposite to the electrode-formed surface with an adhesive. The adhesive bonds the semiconductor element with the reinforcing member while allowing the semiconductor element to be deformed.

[0006] A method of manufacturing the semiconductor device includes a process of: shaving a back surface of a semiconductor wafer including plural semiconductor elements formed therein to thin the semiconductor wafer, a process of bonding a reinforcing member to the back surface of the thinned semiconductor wafer with an adhesive, and a process of dividing the semiconductor wafer and the reinforcing member stuck to the wafer into units of the semiconductor elements.

[0007] Another method of manufacturing the semiconductor device includes a process of: forming a diced groove along a respective border of plural semiconductor elements from an electrode-formed surface of a semiconductor wafer including the semiconductor elements formed therein, a process of attaching a sheet to the electrode-formed surface of the semiconductor wafer including the diced grooves formed thereon, a process of ~~divide~~ diving the semiconductor wafer into units of the semiconductor elements through shaving a back surface of the semiconductor wafer with the sheet attached thereto to thin the semiconductor wafer to a thickness until the back surface reaches the diced groove, a process of bonding a reinforcing plate to a back surface of each semiconductor element with an adhesive, and a process of dividing the reinforcing plate into units of the semiconductor elements after removing the sheet from the electrode-formed surface.

[0008] Still another method of manufacturing the semiconductor device includes a process of shaving a back surface of a semiconductor wafer including plural semiconductor elements, a process of dividing the semiconductor wafer into the semiconductor elements,

and a process of bonding a reinforcing member to a back surface of each semiconductor element with an adhesive.

[0009] The semiconductor device has a semiconductor element that is handled easily and has an increased reliability after being mounted.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Fig. 1A through Fig. 1D illustrate processes in a method of manufacturing a semiconductor device in accordance with an exemplary embodiment 1 of the present invention.

[0011] Fig. 2A through Fig. 2C illustrate processes in the manufacturing method of the semiconductor device in accordance with the embodiment 1.

[0012] Fig. 3 is a perspective view of the semiconductor device in accordance with the embodiment 1.

[0013] Fig. 4A through Fig. 4C illustrate processes of mounting the semiconductor device in accordance with the embodiment 1.

[0014] Fig. 5A through Fig. 5D illustrate processes in a method of manufacturing a semiconductor device in accordance with an exemplary embodiment 2 of the invention.

[0015] Fig. 6A through Fig. 6D illustrate processes in the method of manufacturing the semiconductor device in accordance with the embodiment 2.

[0016] Fig. 7A through Fig. 7C illustrate processes in a method of manufacturing a semiconductor device in accordance with an exemplary embodiment 3 of the invention.

[0017] Fig. 8A through Fig. 8D illustrate processes in the method of manufacturing the semiconductor device in accordance with the embodiment 3.

[0018] Fig. 9A and Fig 9B illustrate processes of mounting the semiconductor device in accordance with the embodiment 3.

[0019] Fig. 10A through Fig. 10D illustrate processes in a method of manufacturing a semiconductor device in accordance with an exemplary embodiment 4 of the invention.

[0020] Fig. 11A through Fig. 11C illustrate processes in the method of manufacturing the semiconductor device in accordance with the embodiment 4.

[0021] Fig. 12 is a perspective view of the semiconductor device in accordance with the embodiment 4.

[0022] Fig. 13A through Fig. 13C illustrate processes of mounting the semiconductor device in accordance with the embodiment 4.

[0023] Fig. 14A through Fig. 14D illustrate processes in a method of manufacturing a semiconductor device in accordance with an exemplary embodiment 5 of the invention.

[0024] Fig. 15A through Fig. 15D illustrate processes in the method of manufacturing the semiconductor device in accordance with the embodiment 5.

[0025] Fig. 16A through Fig. 16C illustrate processes in a method of manufacturing a semiconductor device in accordance with an exemplary embodiment 6 of the invention.

[0026] Fig. 17A through Fig. 17D illustrate processes in the method of manufacturing the semiconductor device in accordance with the embodiment 6.

[0027] Fig. 18A and Fig. 18B illustrate processes of mounting the semiconductor device in accordance with the embodiment 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

(Exemplary Embodiment 1)

[0028] Fig. 1A through Fig. 1D and Fig. 2A through Fig. 2C illustrate processes in a method of manufacturing a semiconductor device in accordance with an exemplary embodiment 1. Fig. 3 is a perspective view of the semiconductor device, and Fig. 4A through Fig. 4C illustrate processes of mounting the device. Fig. 1A through Fig. 1D and Fig. 2A through Fig. 2C illustrate the method of manufacturing the semiconductor device in order of procedure of the method.

[0029] In Fig. 1A, bumps 2, electrodes for external connections, are formed on a top surface of a semiconductor wafer 1 in which plural semiconductor elements are formed. As

shown in Fig. 1B, a sheet 3 is attached to a bump-formed surface (electrode-formed surface), which is the top surface of the wafer 1, and then, the wafer 1 has a back surface opposite the electrode-formed surface thinned while being reinforced with the sheet 3. The back surface is thinned by shaving with a polishing machine having a grinding wheel, by etching with a dry etching apparatus, or by etching with ~~utilizing~~ a chemical reaction of a chemical solution. The wafer 1 is thus thinned to have a thickness of about 50μm.

[0030] Subsequently, a bumper plate 4 is stuck to the back surface of the thinned semiconductor wafer 1. As shown in Fig. 1C, an adhesive 5 is applied to a top surface of a bumper plate 4 formed by shaping a material such as resin, ceramic, metal or the like into a plate. The adhesive 5 is a resin adhesive having a low elastic modulus, and is made of material such as elastomer having a low elastic modulus in bonding for being easily expanded and contracted with a small external force.

[0031] The bumper plate 4 functions as a holding member <u>during</u> ~~in~~ handling of the semiconductor device after the semiconductor elements are separated from one another to form the semiconductor devices, respectively, and also functions as a reinforcing member to protect the semiconductor elements from an external force and impact. Accordingly, the bumper plate 4 has an enough thickness to exhibit a greater flexural rigidity than the semiconductor element. After the bumper plate 4 is attached to the wafer 1, as shown in Fig. 1D, a holding sheet 6 used in a dicing process is attached to an undersurface of the bumper plate 4, and then the sheet 3 is peeled from the electrode-formed surface.

[0032] The bumper plate 4 and semiconductor wafer 1 both held by the sheet 6 are processed in the dicing process. In the process shown in Fig. 2A, a two-stage dicing is performed to cut the bumper plate 4 and wafer 1 along different dicing widths, respectively. Specifically, the wafer 1 is cut with a dicing width b1 to be divided into discrete semiconductor elements 1', while the bumper plate 4 is cut with a dicing width b2 narrower than the width b1 to be divided into discrete bumper members 4'.

[0033] Then, the sheet 6 is peeled from bumper members 4' which are bonded to respective semiconductor elements 1' with the adhesive 5, and thus, discrete semiconductor devices 7, one of which is shown in Fig. 2B, are ~~is~~ provided. Each semiconductor device 7 includes the semiconductor element 1' having bumps 2 functioning as electrodes for external connections, and bumper member 4' functioning as a reinforcing member bonded to a back surface opposite to an electrode-formed surface of the element 1' with the adhesive 5. A size B2 of the bumper member 4' is larger than a size B1 of the semiconductor element 1', and outer edges of the bumper member 4' protrude further ~~more outwardly~~ outward than outer edges of the semiconductor element 1'. The adhesive 5, since being the resin adhesive having low elastic modulus, bonds the semiconductor element 1' to the bumper member 4' while allowing the element 1' to be deformed.

[0034] As shown in Fig. 3, the bumper member 4' including a part code 8 as identification information printed on the top surface of the member 4', and a polarizing mark 9 indicative of a mounting direction printed at the corner similarly to a conventional resin-sealed electronic component. In other words, the bumper member 4' has a reverse surface opposite to a bonded surface of the member 4' and the semiconductor element 1', and the reverse surface is an applied-surface to which the identification information is applied. Then, a discrete semiconductor device 7 is inverted to have the bumper member 4' face upward, and then is subjected to a taping process to be stored on a tape for supplying electronic components to an automatic-electronic-component-mounting apparatus. Thus, the device 7 can be mounted with the mounting apparatus.

[0035] Instead of the semiconductor element 1', a dummy semiconductor device made of a silicon plate having a thickness of 50μm was subjected to a drop test in which the device was dropped from a height of 1m. As a result, damage such as fracture or the like did not occur to the silicon plate at all. According to this fact, it is confirmed that the semiconductor device in accordance with the present embodiment has no problem even if being handled in the same manner as ~~for~~ an ordinary electronic component. Therefore, the semiconductor

device 7 can employ an extremely thin semiconductor element, which is hardly handled upon being used in a conventional resin-sealed device, because the device 7 has a simple structure in which bumper member 4' is simply bonded to the semiconductor element 1' with the adhesive 5.

[0036] Mounting the semiconductor device 7 will be explained hereinafter by ~~with~~ referring to Fig. 4A through Fig. 4C. As shown in Fig. 4A, the device 7 has a top surface of the bumper member 4' sucked and held by a mounting head 10, and then, the device 7 is positioned above a ~~the~~ substrate 11 by the head 10. After aligning the bumps 2 of the device 7 with respective electrodes 12 on the substrate 11, the mounting head 10 is then lowered to mount each bump 2 of the semiconductor element 1' on each electrode 12.

[0037] Subsequently, the substrate 11, with being heated, has the electrodes 12 bonded to the bumps 2 by soldering. As described above, the mounting head 10 holds the bumper member 4' as the holding member while the semiconductor device 7 is handled to be mounted on the substrate 11. The bumps 2 may be bonded to the respective electrodes 12 by a conductive resin adhesive.

[0038] In an assembly including the semiconductor device 7 mounted on the substrate 11, the device 7, for being fixed to the substrate 11, has the bumps 2 bonded to respective electrodes 12 of the substrate 11 as a workpiece. The semiconductor element 1' is thin and is easily bent, and the low elastic modulus material that is easy deformed is used for the adhesive 5. Therefore, as shown in Fig. 4C, when the substrate 11 is deformed by an external force after the mounting, only the semiconductor element 1' and an adhesive layer of the adhesive 5 are ~~is~~ deformed in response to the deformation of the substrate 11.

[0039] Moreover, since the extremely thin semiconductor element has ~~having~~ a thickness of 100μm or less in the semiconductor device in accordance with this embodiment, a stress on the bumps 2 due to a difference between thermal expansion coefficients of the element 1' and substrate 11 is reduced. A conventional electronic component (semiconductor device) having a bump, since employing a thick semiconductor element,

accepts an excessive stress on the bump that is high enough to be able to break the bump. For this reason, an underfill resin or the like is needed for reinforcing between the electronic component having the bump and a substrate. However, the extremely thin semiconductor element 1', after being mounted, reduces the stress on a junction of the device 7 and substrate 11 without reinforcement such as the underfill resin. In addition, the semiconductor device has a simple package structure including the semiconductor element 1' and bumper member 4' both simply bonded with the adhesive 5, thus having an ensured reliability after the mounting.

(Exemplary Embodiment 2)

[0040] Fig. 5A through Fig. 5D and Fig. 6A through Fig. 6D illustrate processes in a method of manufacturing a semiconductor device in accordance with an exemplary embodiment 2 in order of procedure of the method.

[0041] In Fig. 5A, bumps 2 for external connections are formed on a top surface of a semiconductor wafer 1 including plural semiconductor elements formed therein. A sheet 6 is then attached to an undersurface of the wafer 1. As shown in Fig. 5B, the wafer 1 is diced while being held by the sheet 6 to from grooves 1a along respective borders of semiconductor elements 1'. A reinforcing sheet 3 for a thinning process is attached ~~performed~~ to bump-formed surfaces of the elements 1', and then, the sheet 6 is removed. Then, the elements 1', upon being reinforced with the sheet 3, has a set of back surfaces opposite to the bump-formed surfaces 1' thinned. Each element 1' is thinned to a thickness of about 50μm and separated from one another along diced grooves 1a.

[0042] Subsequently, as shown in Fig. 5D, the elements 1' are stuck to a bumper plate 4 with an adhesive 5 applied to a top surface of the bumper plate 4 similarly to the embodiment 1. Then, the thinned semiconductor elements 1' is stuck to a surface coated with the adhesive 5. The adhesive 5 is made of the same material as that described in the embodiment 1.

[0043] After the semiconductor elements is stuck, a holding sheet 6 for another dicing process is applied to an undersurface of the bumper plate 4, as shown in Fig. 6A, and the bumper plate 4 is thus held by the sheet 6 to be thereafter diced. In this process, as shown in Fig. 6B, after the sheet 3 is removed from the bump-formed surfaces of the elements 1', the bumper plate 4 has recesses ~~is cut a recess~~ of a dicing width b2 cut therein for dividing the plate 4 into discrete bumper members 4'. The width b2 is smaller than a dicing width b1 of the recesses ~~which recess~~ is formed among the semiconductor elements 1'. Then, the bumper members 4', upon being bonded to respective elements 1' with the adhesive 5, are each removed from the sheet 6. ~~And consequently~~ Consequently, similarly to Fig. 6C, discrete semiconductor devices 7, the same devices as in the ~~embodiment1~~ embodiment 1, are obtained. The semiconductor devices 7 are ~~is~~ then subjected to a taping process in the same manner as in the embodiment 1.

~~(~~Exemplary Embodiment 3~~)~~

[0044] Fig. 7A through Fig. 7C and Fig. 8A through Fig. 8D illustrate processes in a method of manufacturing a semiconductor device in accordance with an exemplary embodiment 3 of the present invention. Fig. 9A and Fig. 9B illustrate processes of mounting the semiconductor device in accordance with the present embodiment. Fig. 7A through Fig. 7C and Fig. 8A through Fig. 8D illustrate the method of manufacturing the semiconductor device in order of procedure of the method.

[0045] In Fig. 7A, bumps 2, electrodes for external connections, are formed on a top surface of a semiconductor wafer 1 similarly to the embodiment 1 and embodiment 2. Subsequently, as shown in Fig. 7B, a sheet 3 is attached to a electrode-formed surface, which is the top surface of the wafer 1. ~~And the~~ The wafer then has an undersurface thinned while ~~with~~ being reinforced with the sheet 3. Thus, the wafer 1 is thinned to a thickness of about 50μm.

[0046] A holding sheet 6 for a dicing process is then attached to the undersurface of the semiconductor wafer 1, while the reinforcing sheet 3 used for the thinning is removed. Then, the wafer 1 held by the sheet 6 is subjected to the dicing process. In this process, diced grooves 1a are formed as shown in Fig. 7C, and the wafer 1 is then cut along the grooves and divided into semiconductor elements 1'. The elements 1' are removed from the sheet 6, and provided as shown in Fig. 8A.

[0047] Subsequently, the semiconductor element 1' is stuck to a bumper case 14. The bumper case 14, which is a reinforcing member used in the present embodiment, includes a projection 14a provided at a border of the case and a recess portion 14b formed at a portion to which the element 1' is bonded, as shown in Fig. 8B. An adhesive 5 made of the same material as that of the embodiment 1 is applied to the portion corresponding to the element 1' within the recess portion 14b. As shown in Fig. 8C, the element 1' is mounted at the recess portion 14b and bonded to the bumper case 14 with the adhesive 5. Consequently, a semiconductor device 15 is provided. The bumper case 14, upon being bonded to the element 1', has an edge of the projection 14a not project from tips of the bumps 2 of the element 1'.

[0048] The bumper case 14 functions as a holding member during handling the semiconductor device 15 and also functions as the reinforcing member to protect the semiconductor element 1' from external force and impact similarly to the embodiment 1 and embodiment 2. The bumper case 14 protects sides of the element 1' according to the present embodiment, thus improving reliability of the semiconductor device 15. The semiconductor device 15 is then inverted as shown in Fig. 8D and subjected to a taping process. Thus, the device 15 can be mounted with by an electronic component mounting apparatus.

[0049] Mounting the semiconductor device 15 will be described hereinafter while ~~with~~ referring to Fig. 9A and Fig. 9B. As shown in Fig. 9A, the device 15, upon having a top surface of bumper case 14 sucked and held by a mounting head 10, is positioned above a ~~the~~ substrate 11 by the head 10. In the present embodiment, an adhesive 16 is previously applied

to a region (which corresponds to the projection 14a of the bumper case 14) surrounding electrodes 12 on a top surface of the substrate 11. The semiconductor device 15 has the bumps 2 aligned with respective electrodes 12 of the substrate 11, and then, the head 10 is lowered to have the bumps 2 of the semiconductor element 1' mounted on the electrodes 12.

[0050] Thus, the projection 14a of the bumper case 14 contacts with the adhesive 16 on the substrate 11. Subsequently, with being heated, the substrate 11 has the electrodes 12 bonded to the bumps 2 by soldering as shown in Fig. 9B. ~~And then~~ Then, the bumper case 14 is secured to the substrate 11 by the adhesive 16. As described above, even in this embodiment, the mounting head 10 holds the bumper case 14, which is a holding member, during handling of the semiconductor device 15.

[0051] In an assembly including the semiconductor device 15 mounted on the substrate 11, the device 15 is fixed to the substrate 11 through the bonding point of the bumps 2 of the device 15 and the respective electrodes 12 of the substrate 11 as a workpiece, and through the bonding point of the border of the bumper case 14 and the substrate 11. Even in this assembly, the semiconductor element 1' is allowed to be deformed, and has the same advantages as those described in the embodiment 1 and embodiment 2.

[0052] Further, as shown in Fig. 9B, the semiconductor element 1' of the semiconductor device 15 has the top surface and the border entirely sealed after being mounted in the present embodiment. Therefore, the device 15 and electrodes 12 have ~~has~~ junctions that are prevented from having moisture and extraneous matter entering therein ~~the junctions~~, and thus, has an improved reliability after the mounting.

~~(~~Exemplary Embodiment 4~~)~~

[0053] Fig. 10A through Fig. 10D and Fig. 11A through Fig. 11C illustrate processes in a method of manufacturing a semiconductor device in accordance with an exemplary embodiment 4 of the present invention. Fig. 12 is a perspective view of the semiconductor device. Fig. 13A through Fig. 13C illustrate processes of mounting the device. Fig. 10A

through Fig. 10D and Fig. 11A through Fig. 11C illustrate the method of mounting the device in order of procedure of the method.

[0054] In Fig. 10A, bumps 2, electrodes for external connections, are formed on a top surface of a semiconductor wafer 1 including plural semiconductor elements formed therein. As shown in Fig. 10B, a sheet 3 is attached to a bump-formed surface (electrode-formed surface), which is the top surface of the wafer 1. And the wafer 1, upon being reinforced with the sheet 3, has a back surface opposite to the electrode-formed surface thinned. The wafer 1 may be thinned by shaving with a polishing machine having a grinding wheel, by etching with a dry etching apparatus, or by etching utilizing a chemical reaction of a chemical solution. The wafer 1 is thus thinned to a thickness of about 50μm.

[0055] Subsequently, a bumper plate 4 is stuck to the back surface of the thinned semiconductor wafer 1. As shown in Fig. 10C, an adhesive 50 is applied on a top surface of bumper plate 4 at each portion corresponding to each semiconductor element of the wafer 1. The bumper plate 4 is formed by shaping a material such as resin, ceramic, metal or the like into a plate. In Fig. 10C, the adhesive 50 is applied to only a portion corresponding to a center of each semiconductor element. The adhesive 50 is made of resin having an elastic modulus lower than that of the bumper plate 4.

[0056] The bumper plate 4 functions as a holding member during ~~in~~ handling of the semiconductor device after the semiconductor elements are separated from one another to form the semiconductor devices, respectively, and also functions as a bumper to protect the semiconductor elements from external force and impact. Accordingly, the bumper plate 4 has an enough thickness to exhibit greater flexural rigidity than the semiconductor element. After the bumper plate 4 is applied to the wafer 1, as shown in Fig. 10D, a reinforcing sheet 6 used for a dicing process is applied to an undersurface of the bumper plate 4, and then, the sheet 3 is peeled from the electrode-formed surface.

[0057] The bumper plate 4 and semiconductor wafer 1 both reinforced with the sheet 6 are then ~~is~~ subjected to the dicing process. In the process, as shown in Fig. 11A, two-stage

dicing is performed to cut the bumper plate 4 and wafer 1 with different dicing widths, respectively. Specifically, the wafer 1 is cut with a dicing width b1 and divided into discrete semiconductor elements 1', while bumper plate 4 is cut with a dicing width b2 narrower than the width b1 and divided into discrete bumper members 4'.

[0058] The sheet 6 is then peeled from the bumper members 4' bonded to respective semiconductor elements 1' with the adhesive 50, and consequently, discrete semiconductor devices 30 are provided, similarly to Fig. 11B. Each device 30 includes the semiconductor element 1' having the bumps 2 functioning as electrodes for external connections, and the bumper member 4' functioning as a holding member during the handling. The holding member is bonded to the back surface opposite to the electrode-formed surface of the element 1' with the adhesive 50. A size B2 of the bumper member 4' is larger than a size B1 of the semiconductor element 1', and therefore, an outer edge of the bumper member 4' protrudes more outward than an ~~a~~ outer edge of the element 1'. Only the center of semiconductor element 1' is bonded to the corresponding portion of the bumper member 4' with the adhesive 50. The semiconductor device 30, since having an outer border of the semiconductor element 1' free against the bumper member 4', is resistant to warping even if the element 1' and bumper member 4' have there ~~has the~~ sizes change due to thermal expansion.

[0059] As shown in Fig. 12, the bumper member 4' may include a part code 8 as identification information printed on a top surface thereof and a polarity mark 9 indicative of a mounting direction printed at a corner thereof similarly to a conventional resin-sealed electronic component. In other words, a reverse surface, positioned opposite to a junction of the bumper member 4' and semiconductor element 1', of bumper member 4' is a surface to which the identification information is applied. Then, the discrete semiconductor device 30 is inverted to have the bumper ~~members~~ member 4' face upward, and then, is subjected to a taping process to hold the device with a tape for supplying electronic components. Thus, the device 30 can be mounted with an electronic component mounting apparatus.

[0060] ~~instead~~ Instead of the semiconductor element 1', a dummy semiconductor device made of a silicon plate having a thickness of 50μm was subjected to a drop test in which the device was dropped from a height of 1m. As a result, damage such as fracture or the like did not occur to the silicon plate at all. According to this fact, it is confirmed that no problem ~~occur~~ occurs even if the semiconductor device in accordance with the present embodiment is handled in the same manner as an ordinary electronic component. The semiconductor device 30 can employ an extremely thin semiconductor element, which is hardly handled when being used in a conventional resin-sealed device, because the device 30 has a simple structure in which the bumper member 4' is simply attached to the center of the semiconductor element 1' with the adhesive 50.

[0061] Referring to Fig. 13A through Fig. 13C, mounting the semiconductor device 30 will be described. As shown in Fig. 13A, the device 30, having a top surface of the bumper member 4' by a mounting head 10, is sucked and positioned above a substrate 11 by the head 10. After the device has the bumps 2 aligned with respective electrodes 12 of the substrate 11, the mounting head 10 is then lowered to mount the bumps 2 of the semiconductor element 1' on the electrodes 12, respectively.

[0062] Subsequently, the substrate 11, with being heated, has the electrodes 12 bonded to the bumps 2 by soldering. As described above, the mounting head 10 holds the bumper member 4', which is the holding member, during handling to mount the semiconductor device 30 on the substrate 11. The bumps 2 may be bonded to respective electrodes 12 by a conductive resin adhesive.

[0063] In an assembly including the semiconductor device 30 mounted on the substrate 11, the device 30 is fixed to the substrate 11 through the bonding of the bumps 2 of the device 30 to the electrodes 12 of the substrate 11 as a workpiece. As shown in Fig. 13C, when the substrate 11 is deformed by an external force after the mounting, only the semiconductor element 1' is deformed in ~~responsive~~ response to the deformation of the substrate 11 because the element 1' is thin and is easily bent. In the present embodiment,

the element 1' has only the center bonded to the bumper member 4', and thus, can be deformed without being restrained by the bumper member 4'.

[0064] Moreover, an extremely thin semiconductor element having a thickness of 100μm or less, upon being employed in the semiconductor device in accordance with this embodiment, accepts a reduced stress on bumps 2 due to a difference between thermal expansion coefficients of the semiconductor element 1' and substrate 11. In a conventional electronic component (semiconductor device) having a bump, since ~~employing~~ a thick semiconductor element is employed, accepts an excess stress on the bump, and thus, the component may cause disconnection between the bump and an electrode of a substrate. For this reason, an underfill resin or the like is needed for reinforcement between the electronic component and the substrate. However, the extremely thin semiconductor element 1' in accordance with the present embodiment, after being bonded, reduces a stress on a junction of the semiconductor device 30 and substrate 11 without reinforcement such as the underfill resin. In addition, the semiconductor device 30 has a simple package structure including the semiconductor element 1' and the bumper member 4' simply bonded together with the adhesive 50, thus having an ensured reliability after this device 30 is mounted.

~~(~~Exemplary Embodiment 5~~)~~

[0065] Fig. 14A through Fig. 14D and Fig. 15A through Fig. 15D illustrate processes in a method of manufacturing a semiconductor device in accordance with an exemplary embodiment 5 of the present invention, and illustrate the method in order of procedure thereof.

[0066] The present embodiment is substantially the same as the embodiment 2 except for the process of sticking the semiconductor elements 1' to the bumper plate 4 with an adhesive. As shown in Fig. 14D, the semiconductor elements 1' are stuck to the bumper plate 4. In this process, an adhesive 50 is applied to each portion corresponding to each element 1' on a top surface of the bumper plate 4, and a thinned semiconductor ~~elements~~

element 1' is stuck to a surface coated with the adhesive 50. In this drawing, the adhesive 50 is applied to only the portion corresponding to a center of each semiconductor element, and is made of material having an elastic modulus lower than the bumper plate 4.

[0067] The rest of the procedure for obtaining the semiconductor devices 30 is the same as that of the embodiment 2.

(Exemplary Embodiment 6)

[0068] Fig. 16A through Fig. 16C and Fig. 17A through Fig. 17D illustrate processes in a method of manufacturing a semiconductor device in accordance with an exemplary embodiment 6 of the present invention, and illustrate the method in order of procedure thereof. Fig. 18A and Fig. 18B illustrate processes of mounting the semiconductor device.

[0069] The present embodiment is substantially the same as the embodiment 3 except for the process of sticking each semiconductor element 1' to the bumper case 14 with an adhesive. The adhesive 50 is applied to only a portion of the recess portion 14b corresponding to a center of the element 1'. As shown in Fig. 17C, the element 1' is mounted at the recess portion 14b, the adhesive 50 bonds the bumper case 14 to the element 1', and consequently, a semiconductor device 35 is provided. The bumper case 14 bonded to the element 1' has an edge of a projection 14a not projecting from a tip of the bump 2 of the element 1'.

[0070] The bumper case 14 functions as a holding member during in handling of the semiconductor device 35, and also functions as a bumper to protect the semiconductor element 1' from external force and impact similarly to the embodiment 4. Moreover, the bumper case 14 protects a side of the element 1' in this embodiment, thus improving reliability of the semiconductor device 35. As shown in Fig. 17D, the semiconductor device 35 is then inverted and subjected to a taping process. Thus, the device 35 can be mounted by an electronic component mounting apparatus.

[0071] With referring to Fig. 18A and Fig. 18B, mounting the semiconductor device 35 will be described. As shown in Fig. 18A, the device 35, having a top surface of bumper

case 14 sucked and held by a mounting head 10, is positioned above a ~~the~~ substrate 11 by the head 10. In the present embodiment, an adhesive 16 is previously applied to a region (which corresponds to the projection 14a of the bumper case 14) surrounding electrodes 12 on a top surface of the substrate 11. With ~~aligning~~ the bumps 2 of the device 35 aligned with respective electrodes 12 of the substrate 11, the head 10 is then lowered to mount the bumps 2 of the semiconductor element 1' on the electrodes 12.

[0072] Thus, the projection 14a of the bumper case 14 contacts with the adhesive 16 on the substrate 11. Subsequently, the substrate 11, upon being heated, has respective electrodes 12 bonded to the bumps 2 by soldering as shown in Fig. 18B, and thus, the bumper case 14 is secured to the substrate 11 by the adhesive 16. As described above, even in this embodiment, the mounting head 10 holds the bumper case 14, which is the holding member, during the handling of the semiconductor device 35.

[0073] In an assembly including the semiconductor device 35 mounted on substrate 11, the device 35 is fixed to the substrate 11 through the bonding of bumps 2, as electrodes of device 35, to respective electrodes 12 of the substrate 11 as a workpiece, and through the bonding of a border of the bumper case 14 to the substrate 11. Even in this assembly, the semiconductor element 1' can be deformed, and the same advantage as that of the semiconductor element described in the embodiment 4 is obtained.

[0074] Further, as shown in Fig. 18B, the semiconductor element 1' of the semiconductor device 35 has a top surface and border entirely sealed after being mounted in the present embodiment. Therefore, the device is protected from moisture and extraneous matter entering junctions of the device 35 and electrodes 12, and thus has an improved reliability after the mounting.